is more rudimentary than in *Zschokkeella*. I should distinguish the various genera thus:—

I. Excretory system forms a network in each segment. Receptaculum seminis long and forming end of vagina. Cirrus sac small.
  A. Genital pores median on edge of segment. Testes forming a continuous row. No vesicula seminalis. Uterus well developed at first . . . . . *Zschokkeella*.
  B. Genital pores posterior on edge of segment. Testes in two groups. Large vesicula seminalis present. Seminal ducts form a network. Uterus never well developed. *Inermicapsifer*.

II. No excretory network. Receptaculum short and globular along the course of vagina. Cirrus sac rather large.
  A. Genital pores on conspicuous papilla. Testes forming continuous row. Uterus never well developed. *Thysanotœnia*.

This arrangement is naturally only tentative, since we are at present in need of more information concerning the majority of the species already known from the Hyrax and enumerated by Janicki in the paper which has been so often referred to. There are also points in the structure of the species referred to the genus *Zschokkeella* which demand further investigation.

32. Additional Notes on the Living Specimens of the Australian Lung-fish (*Ceratodus forsteri*) in the Collection of the Zoological Society of London. By Bashford Dean.*

[Received February 9, 1912: Read April 2, 1912.]

(Text-figures 84 & 85.)

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The two specimens of the Australian Lung-fish in the Zoological Society's collection have been living under unchanged conditions since 1898, *i. e.* about fourteen years. In this time they have been observed repeatedly by zoologists, whose interest in these important and rare batrachian-like fishes has led them, in several instances, to publish their notes in detail. There is still, however, much to learn about the habits of these fishes, and it is to be hoped that the opportunity will be seized generally to observe the present specimens, especially

* Communicated by the Secretary.

since it is fair to assume that they are living under fairly normal conditions. In this connection it may be mentioned that the fishes have been subjected to no changes in their aquarial habitat; indeed, they have remained practically undisturbed for over a decade.

Among the notes dealing with these specimens are those of the present writer, published six years ago in the 'Proceedings' of the Zoological Society of London (1906, vol. i. pp. 168–178), a contribution which gave also data about *Ceratodus* summarized from earlier literature. In this paper details were recorded regarding the movements of the fishes, their mode of breathing, both with gills and lungs, their manner of feeding, their nocturnal activity, and in general their salamander-like habits.

The writer had again the opportunity of observing these specimens during June 1911; his supplemental notes are as follows:—

Colour.—One of the fishes, the larger one, remains notably darker than the other. This distinction in colour, therefore, is neither abnormal nor seasonal. Nor can there be vast adaptive colour changes in *Ceratodus*, for the reaction to similar surroundings would then be the same in the two fishes. Is the darker specimen a male?

So far as could be learned, the fishes have shown no evidence of sexual activity. The colours have remained constant, and there have been no signs of the brilliant tones noted by Schmeltz (1876, J. Mus. Godeffr., vol. viii. p. 138). According to his account, the ventral side of *Ceratodus* is of a deep orange-red, and several scales on the sides are margined with red; nothing is said, however, of the relation of these colours to the season. From the characters of the present specimens, and by analogy with *Amia*, we can safely conclude that the tones of orange and red appear only at the time of spawning. In *Amia*, aquarium-kept fishes show no bright colours, but under native conditions the male fish develops wonderful brilliancy; the spot at the base of the tail is conspicuous, red scale-margins appear, and the hinder abdomen glows with tones of orange.

It was noted (1911) that the paired fins were margined with a narrow white band. Could this have been an indication of a breeding colour? No coloration of this kind was seen on the edges of the unpaired fins.

Size.—At present the darker specimen measures $33\frac{1}{2}$ inches, the lighter $29\frac{1}{2}$ inches, having grown but a very few inches during the past seven years. They have reached, accordingly, nearly their greatest length, Macleay leading us to infer that 3 feet is about their maximum (Cat. Austr. Fishes, p. 284). Exceptionally, however, a specimen may measure 45 inches, such a case having been cited by O'Connor (1897).

Age.—The present specimens give us an idea of the age to which *Ceratodus* may attain. We have in the first place data that they have grown, broadly speaking, at the rate of three quarters of an

inch annually for the last thirteen years. At this rate the present fishes are over forty years old, and a fish of the record size (45 inches) would be over sixty. But this assumes that the rate of growth in length is approximately uniform in fishes of different ages. In point of fact it is known that fishes in all groups grow quickly when young, and slowly, if at all, when old: it is also known that under favourable conditions a fish may grow with far greater rapidity. In the case of *Ceratodus* the rate of growth of the young is as follows :—

Length of specimen. inches	*Age.*	
$\frac{8}{16}$	At hatching.	'Notes from stages reared in balanced aquaria in Gayndah, Queensland, by Mr. Thomas Illidge.)
$\frac{12}{16}$	$\frac{1}{4}$ month.	
$\frac{9}{16}$	$1\frac{3}{4}$ month.	
$\frac{11}{16}$	2 months.	
1	$2\frac{1}{2}$ months.	
$1\frac{1}{8}$	6 months.	
$1\frac{1}{2}$	7 months.	
$2\frac{3}{16}$	$7\frac{1}{2}$ months.	
$2\frac{5}{8}$	8 months.	

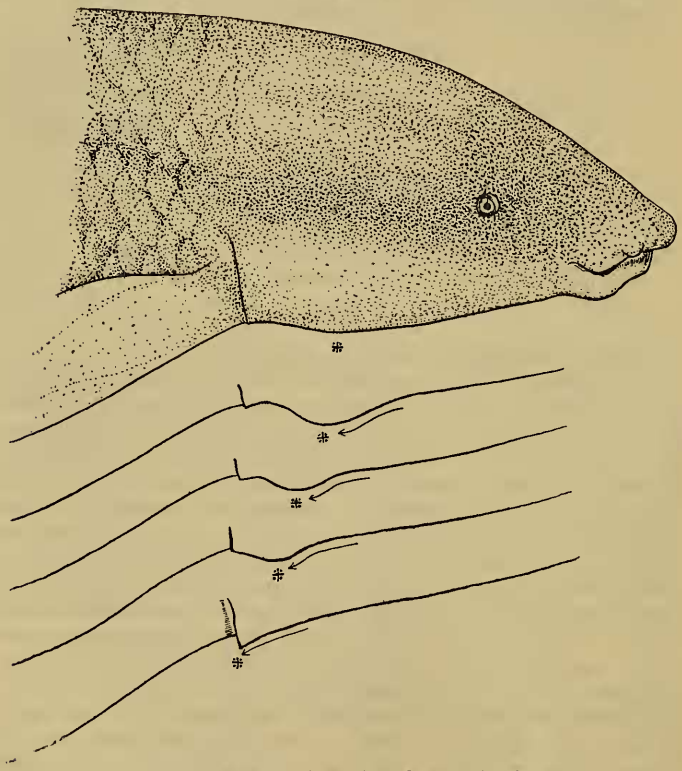
In stages lately hatched the growth is seen to be rapid, its rate suggesting that a specimen 12 inches in length might be not older than a year. The rate, however, changes notably when the young fish no longer subsists on its yolk. In fact, for a period of about two months it actually decreases in size, a state of affairs, however, probably abnormal and due to the lack of proper food in the aquarium. Young an inch long are nine weeks old; young two inches long are over seven months old. At the end of the first year the young *Ceratodus* measures, we infer, about five inches, a rate of growth which would be not unlike that in young *Amia*, gar-pikes, or in a number of teleostean fishes. If the analogy with known ganoids continues, a two-years' *Ceratodus* would measure 8–9 inches; and a specimen 25 inches in length, approximately the size of one of the present fishes when it appeared in London, is estimated to be from eight to ten years old; this added to the thirteen years of their living in the Society's aquarium, makes the total age of the present specimens between, roundly, twenty and twenty-five years. Older and larger specimens it is fair to credit with great age, probably fifty years.

Breathing.—The aquatic respiration of *Ceratodus* varies considerably according to the temperature of the water, but its range has not been observed. In September (1904), on a cool day, with water temperature not far from 65° Fahrenheit, the respiratory movements were "slow and regular; the opercular cavity filled and emptied about twelve times a minute." In late June, when the water temperature was nearly 75°, the successive

movements of the gills varied from twenty-two to thirty-one a minute. Both fish had long been quiet; if their movements had been active there is no doubt that this rate would have been notably exceeded.

Rhythmic movements in breathing are well shown in the opercular membrane. In the early stage of breathing the cheek in the subopercular region is seen to dilate slowly and strongly; this dilated region is then passed (rather slowly) backward, and

Text-fig. 84.



Opercular movement in breathing of *Ceratodus forsteri*.
The crest of the undulatory wave is indicated by the asterisk.

its enclosed water is discharged (text-fig. 84). During this process the dilated part becomes more and more conspicuous until the final discharge, and at that moment the free rim of the gill-opening is thrown outward and drawn forward, exposing the lighter coloured hinder border of the gill-slit. The free border up to that time has been closely apposed to the head.

It was earlier noted that *Ceratodus* is a "nostril breather."

The mouth itself showed no noticeable movement of opening or closing; it was indeed hardly open, the gape scarcely more than $\frac{1}{8}$ inch. During the later observations, the mouth was seen slightly to open and close; its maximum gape noted (measured close to the glass) was $\frac{1}{4}$ inch, its minimum $\frac{1}{8}$ inch. The opening of the mouth was here doubtless correlated with the higher temperature of the water and the more rapid respiratory movements. In general, however, the mouth margin was almost motionless, the fish breathing through the nostrils.

In the matter of breathing air at the surface, *Ceratodus* shows greater variability than earlier noted. On one occasion over seventy minutes elapsed without either fish coming to the surface.

Feeding.—Little was added to the former notes. The only detail suggests that minute food, in the form of algæ together with vegetable débris, forms a part of the normal diet. It was observed that the fishes would "nose" about in corners and suck in this finer material. In the process little pebbles would sometimes be taken in and retained for a few moments, then rejected—the process several times repeated, in a fashion which suggested that the stones thus mouthed yielded food sought for by the fish. It was noted in this connection that the stones in the aquarium were in many cases well coloured with algæ.

Text-fig. 85.

Pectoral fin of *Ceratodus forsteri*, showing regenerating margin.

Movements.—The writer's preceding paper gave a number of figures showing characteristic movements of *Ceratodus*. The only addition to this series would be a variant of the fig. 11 there given; the right hand pectoral remained in its resting position (as in fig. 14); the left, however, was suddenly twitched up over the back several times (as in fig. 11), but in this case brushed close to the body, giving the observer the amusing impression that the fish was thoughtfully rubbing its head. The habit was curiously unlike that of a fish; it suggested rather the movement of a tetrapod; and a very similar movement is known in urodeles.

Regeneration.—The larger (dark coloured) specimen had suffered an injury to the left ventral fin; a portion of it near the tip

had been lost and the margin was regenerating. Text-fig. 85 illustrates how far this process had extended. It will be seen that the restitutive proliferations were most active along the free distal margin of the fin. Here several (four) eminences were present, each suggesting the pointed tip of the fin; there can, however, be no doubt as to which of these *is* the terminal one, since the skeleton of the fin can be followed into the lowest of these lappets. The case is evidently akin to one known to teratologists, for when certain areas in injured limbs of batrachians are stimulated, there appears polydactyly or polypody. It may therefore be worthy of record that a similar condition occurs in the lung-fish *Ceratodus*.

33. The Circulatory System of the Common Grass-Snake (*Tropidonotus natrix*). By Chas. H. O'Donoghue, B.Sc., F.Z.S., Assistant to the Jodrell Professor of Zoology, University College, London.

[Received April 1, 1912: Read April 23, 1912.]

(Plates LXX.–LXXII. and Text-figures 86–91.)

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I. Introduction.

Our knowledge of the circulatory system in snakes is far from exhaustive; indeed, we have only a complete account of the vessels in the Python by Hopkinson and Pancoat (**25**), and a later and a more full one by Jaquart (**26**), and in *Pelophilus madagascariensis* by Gadow *. Although *Tropidonotus natrix* is

* This is incorporated in the account given by Hoffmann (**23**).